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Consequences of Quarantine During the COVID-19 Pandemic on Food Intake and Body Weight: A Systematic Review

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Abstract

Background: Due to the coronavirus disease (COVID-19) pandemic, some authorities have implemented measures to control the spread of the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), such as quarantine. The aim of this systematic review was to summarize the results of the studies that investigated changes in eating habits, food intake, and body weight during the COVID-19 quarantine.

Methods: This review followed the recommendations of the PRISMA protocol and has registration in the PROSPERO under number CRD42020212491. Searches used databases PubMed, Medline, Scielo, and Lilacs. Two authors conducted the selection process blindly and independently using the Rayyan software (QCRI). Of 5,248 papers, we included 28 studies.

Results: Most of the included studies in this review presented data on changes in food intake (n = 22). These changes were especially towards the adoption of unhealthy eating habits such as an increase in the consumption of snacks and sweets; and a decrease in the intake of vegetables, fruits, fish, and dairy products (n = 21). Concerning body weight, the main change was towards weight gain (1.5 to 4.5 kg), which was positively associated with age (elderly); socioeconomic level (average socioeconomic level); increase of the intake of snacks, sweets, fried foods, and fast foods; and low consumption of vegetables. Besides, weight gain was inversely associated with physical activity and positively associated with sedentary time (n = 14).

Conclusion: In this sense, the summarized evidence points to a change in eating habits, food intake, and body weight, as well as a relevant association between unhealthy eating choices and weight gain during quarantine. The COVID-19 quarantine caused an interruption in the routine of daily life, which generated an impact on mental health,

eating habits, and physical activity. This review showed that during the quarantine some individuals changed their eating habits, mainly towards the adoption of unhealthy habits and gained weight.

Keywords: COVID-19, SARS-CoV-2, quarantine, food intake, eating habits, body weight changes, weight gain

Introduction

In December 2019, an unknown disease first identified in Wuhan, Hubei, China, named as 2019-nCoV and later renamed COVID-19 by the World Health Organization (WHO), warned the medical and scientific communities (1,2). This disease quickly spread in several countries and on 11 March 2020 was declared as a pandemic by the WHO (3). The statistical data of the COVID-19 of July 2021 show that more than 184 million people already were infected and more than 3,9 million died worldwide (4). Its symptoms range from those most common such as cough and fever to those more severe such as shortness of breath, and other uncommon ones, such as loss of taste and smell (5).

The COVID-19 is caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) that spreads from person to person through droplets generated by coughing, sneezing, and talking. Containment strategies in the face of the growing number of cases revolve around social distancing, quarantine, and public places' closure. Despite the benefits provided by such strategies in combating the spread of the virus, these measures can favor the occurrence of adverse health effects, especially because they can cause an interruption in the practice of physical activity, an increase of the risk of anxiety and boredom due to social isolation, as well as can negatively affect food choices. (3,6-9).

Quarantine is describing as a measure to isolate those who have contact with an infectious disease and, subsequently, to prevent its spread. There is also the reverse quarantine, a measure that isolates those belonging to the greatest risk of contracting the disease. These measures differ from isolation, a measure of distance from those affected by the infectious disease during the disease incubation period (10).

The lifestyle has undergone many changes in the face of COVID-19 quarantine, with emphasis on the increase of food consumption, decreased physical activity, increased sedentary time, excessive screen time, and poor sleep quality (11-13). These changes can have been generated by the psychological and restrictive impact caused by this measure. The quarantine can have a direct impact on mental health, especially on the development of anxiety, distress, a feeling of loss of control, loneliness, depressive symptoms, and post-traumatic stress disorder (14). All these feelings contribute to the worsening of the quality of food, with an increased risk of developing “emotional eating” and weight gain (15).

Although the WHO published that good nutrition is crucial for health, particularly when the immune system might need to fight back (16), changes in food intake and eating habits during COVID-19 quarantine may not be in line with the recommendation. Some studies have demonstrated that COVID-19 quarantine contributed to increased intake of energy, sodium, and fat; and decreased fruits and vegetables consumption (3,6,17). These negative changes in dietary patterns may result in weight gain, activation of the innate immune system and inhibition of the adaptive, increase in the production of inflammatory mediators, and other factors that can influence COVID-19 (17,18). On the other hand, healthy dietary patterns including a high intake of fruits and vegetables and low consumption of sugar and saturated fats can prevent chronic diseases and improve related-chronic low-grade inflammation (19-21).

In addition to changes in food intake, some studies also have shown that during COVID-19 quarantine there was a change in body weight, especially towards to increase of the self-reported weight (22,23). Excessive weight gain can lead to obesity that is increased worldwide and characterized by an increase of body fat (24) and low-

grade inflammation, which is a recognized link between obesity and other chronic diseases (25,26).

Emerging evidence shows that obesity can be a risk factor for poor outcomes by COVID-19 and still a predictor of mortality (27-29). This occurrence can potentiate the aggravating factors of COVID-19 due to the increase of pro-inflammatory adipokines that contribute to establishing inflammation and oxidative stress. Moreover, obesity seems to impact lung function and immune responses (30,31). Besides, obesity is associated with some comorbidities, such as hypertension and diabetes, which also have been considered risk factors for complications of the COVID-19 (32). However, it's important to emphasize that there are other factors important that influence the mortality by COVID-19, such as age, e.g. elderly individuals are more likely the complications and mortality when compared with younger individuals (33).

In this sense, the aim of the present systematic review was to compile the studies that investigated changes in eating habits, food intake, and body weight during the COVID-19 quarantine. We summarize the main changes in eating habits, food intake, and body weight resulting from quarantine, as well as the factors that impacted these changes. In addition, we investigate whether changes in the food intake were associated with the change in weight body.

Methods

This is a systematic review guided by the following question: What are the consequences of quarantine during the COVID-19 pandemic on eating habits and body weight? This review follows the recommendations of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) and has a registration in International Prospective Register of Systematic Reviews (PROSPERO) under number CRD42020212491.

Searches for articles were in the databases: National Library of Medicine, Bethesda, MD (PubMed), Scientific Electronic Library Online (SciELO), Latin-American and Caribbean System on Health Sciences Information (LILACS), and Medical Literature Analysis and Retrieval System Online (Medline), without delimiting the search period and conducted between October 2020 and March 2021. We used the descriptors "COVID-19", "Food Intake", "Nutrition" and "Eating Behavior" indexed in the Medical Subject Headings (MeSH), their related terms, and their combination by the boolean operators AND and OR in different ways in these databases (**Figure 1**).

Two authors (PMP and NMCO) independently made the paper selection using the Rayyan QCRI website, the Systematic Reviews web app. This selection is according to a protocol previously established by the authors, where authors selected the articles by reading the titles and abstracts and later by reading them in full. The inclusion criteria were original articles, published in English, Portuguese or Spanish, conducted with adolescents, adults, and elderly individuals with or without underlying diseases, and in whose paper the main objective was to assess the influence of quarantine on changing food intake and/or body weight. The exclusion criteria were reviews, studies conducted with children, original studies conducted with animals, and those that did not obtain relevant information to clarify the guiding question. These criteria were adopted so that the objectives previously established were achieved (**Table 1**).

The following data were extracted and compiled independently by 2 authors (PMP and NMCO): first author, year of publication, country, study design, sample, sample size, objectives, and outcomes concerning changes in food intake and body weight. The data are in alphabetical order followed by the name of the first author of the study.

Two authors (PMP and NMCO) also evaluated the article's methodological quality. The cross-sectional studies were assessed using a checklist with questions focused on cross-sectional studies, Checklist for analytical cross-sectional studies, Joana Briggs Institute (34). Then, the same authors classified articles as low (<50%), moderate (50-70%), and high quality (> 70%), according to the degree of contemplation of criteria related to the clarity of the inclusion of individuals in the study, description of the scenario, the measurement made validly and reliably. The observational and longitudinal studies were assessed by the tool for assessing Risk of bias in non-randomized studies of interventions (ROBINS-I). The authors classified the articles as moderate or low risk, according to the domains specified in ROBINS-I, which include (1) bias due to confounding, (2) bias in the selection of participants into the study, (3) bias in classification of interventions, (4) bias due to deviations from intended interventions (5) bias due to missing data, (6) bias in the measurement of outcomes, (7) bias in the selection of the reported result and (8) overall risk of bias (35).

Results

Selected Studies

The search identified 5,248 articles. Of these, 28 articles composed this review. The years of publication of the studies were 2020 and 2021. Most articles have a cross-sectional design (n = 25), longitudinal (n= 2) and retrospective observational study (n= 1). Sample sizes vary, with a population of 72 to 41.923 individuals, including adolescents, adults and the elderly. Most country studies were from Europe, such as Spain (n = 7) (2,17,36-40) , Italy (n = 5) (41-45), Poland (n = 3) (23,46,47), Germany (n = 1) (48) and the Netherlands (n = 1) (49) followed by China (n = 2) (50,51), United States (n = 1) (52), Chile (n = 1) (53), United Arab Emirates (n = 1) (54), Zimbabwe (n

= 1) (55), Lithuania (n = 1) (22), United Kingdom (n = 1) (56), Brazil (n = 1) (57). Other studies included countries in Europe, Africa, Asia and America (n = 1) (58), and which included individuals from Italy, Spain, Chile, Colombia and Brazil (n = 1) (18) (**Table 2 and 3**).

Changes in Food Intake and Eating Behavior

Most of the included studies presented data on changes in food intake (n = 22) (2,17,18,22,36,37,39,40,42,44,46-51,53-58). In this sense, some studies have found increased food intake (n = 2) (36,42) or the number of meals (n = 5) (36,46,47,54,58). The adoption of healthy eating habits reported by some studies (n = 11) it concerns the increased consumption of fruits, vegetables, fish, dairy products, grains, water, and decreased consumption of fast food, sweets, sweet drinks, and ready-made foods. The consumption of fruits and vegetables increased by up to 37% and 43%, respectively, fish and dairy products by 30%, grain by 37%, and water by 3.7%, while reduction in fast food consumption went from 44.6% to 64%, ready-to-eat foods in 2%, sweet foods in 50% and sweet drinks in 30% during quarantine (2,17,18,22,36,39,42,44,46-50,53-55) (Table 2).

Other studies (n = 21) reported unhealthy eating habits related to an increase in snacks and sweets, and a decrease in vegetables, fruits, fish, dairy products, vegetables, and soy products. The consumption of snacks and sweets increased 51.8%, 50%, respectively. The consumption of vegetables and fruits decreased 60%, fish to 57.2%, dairy products 30% and vegetables 70% (2,17,18,22,36,37,40,42,44,46-51,53-58).

Some studies have found changes in alcohol intake (n = 7), with a decrease during quarantine by up to 57.3%, and an increased by up to 18.3% (17,22,36,39,46,55,58).

Some articles evaluated factors that impacted food intake. The reported factors were boredom/solitude by 36% and anxiety/depression by 34.7% of those who participated in one study (44); eating in response to the sight and smell of food by 65%, eating when stressed by 52%, anxious by 41%, and bored by 73% of the respondents in another study (52); and the increased mental stress in a third study (48). The study of Zachary et al. (52) found that a large increase in eating in response to stress is one of the risk factors for weight gain, ranging from 5 to 10 pounds and the study of Huber et al. (48) found that mental stress was associated with increased of the amount of food during quarantine.

Changes in Body Weight

In this review, fourteen studies reported changes in body weight (22,23,36-38,40,41,43-46,52-54). Regarding body weight, fourteen reported weight gain (22,23,36-38,40,41,43-46,52-54), four weight loss (23,36,52,53), and five weight maintenance (22,40,52-54). Moderate studies increased body weight by up to 52.7%, with an average increase of 0.4 to 4.5 kg (38,52). This weight gain was positively associated with age (elderly) (54), socioeconomic level (average socioeconomic level) (53), consumption of snacks (22,37), sweets (44), fried foods and fast food (53) and low consumption of vegetables (53).

Weight gain also had an inverse association with physical activity and a positive association with sedentary time (22,53) (Table 3). Weight loss was reported by a smaller portion of 4% to 31.1% and with an average loss greater than 4.5 kg, with the reported weight maintenance being up to 68.5% of respondents (36,52,53).

Quality Assessment of Articles

The articles included obtained a positive evaluation in general, and all obtained a positive evaluation, none of the criteria related to the analysis performed (n = 25),

followed by the one referring to the description of the study scenario (n = 25), validation and confidence of the evaluation method of the study (n = 25). Study exposure (n = 25), definition of parameters for measuring variables (n = 24), definition of inclusion criteria (n = 22). The criteria for identifying confounding factors obtained intermediate adherence (n = 15). Standardization and objectivity criteria in determining conditions (n = 13) and strategy for dealing with confounding factors have been poorly met (n = 10).

The three studies evaluated by ROBINS-I tool showed in general a low risk, according to the eight domains. The articles were judged within each domain and presented a moderate risk of bias due to confounding (n = 3), low risk of bias in the selection of participants into the study (n = 2), moderate risk of bias in the selection of participants into the study (n = 1), low risk of bias in classification of interventions (n = 3), low risk of bias due to deviations from intended interventions (n = 3), low risk of bias due to missing data (n = 3), moderate risk of bias in the measurement of outcomes (n = 3), low risk of bias in the selection of the reported result (n = 3), and low risk of overall bias (n = 3).

Discussion

To our knowledge, this is the first systematic review that compiled evidence about the influence of COVID-19 quarantine on changes in food intake, body weight, and its inter-relationship. In this sense, eating habits were healthier or unhealthier than those observed before quarantine, which was related to body weight changes (**Figure 2**).

The adoption of healthy eating habits found in this review may be an essential strategy for strengthening the immune system, in order to improve response to infections (59). The Food and Agriculture Organization of the United Nations (FAO) recommends that during the COVID-19 pandemic, people adopt a healthy diet to

support the immune system functions. In this sense, this agency recommends the consumption of a diet rich in fruits, vegetables, whole grains, nuts, and healthy fats such as oils rich in unsaturated fatty acids; a limited intake of foods with high amounts of fats, sugar, and salt; a regular water consumption; and limited alcohol consumption (60).

The immunological system is active full-time, thereby, when pathogens agents, such as the SARS-CoV-2, infect a human cell, innate and adaptive immune response, as well events mediated by the complement system may be a trigger to control the infection and eliminate the pathogen. In this perspective, the induction of an adequate host immune response can protect the organism against more severe complications of diseases such as COVID-19. On the other hand, if the generated immune response is insufficient, may occur, for example, increased viral replication, resulting in tissue damage (61). Several nutrients are involved with the adequate immune response, thus, the adoption of a healthy diet is important for the adequate supply of these nutrients (62).

Considering this context of immunity, the increased consumption of fruits, vegetables, fish, and dairy products found in this review was beneficial. For example, fruits and vegetables contain micronutrients that act on the adaptive immune system, production of antibodies, anti-inflammatory regulation through antimicrobial activity, among other aspects of combating viral infections (63,64). Interestingly, Hermsdorff et al. (25) showed that higher consumption of fruits and vegetables was associated with a lower mRNA expression in peripheral blood mononuclear cells (PMBC) of certain pro-inflammatory markers, including the transcription of nuclear factor- κ B (NF- κ B). In addition to essential vitamins and minerals, fruits and vegetables are also important

sources of antioxidants, which allow the maintenance of immune cell function, through protection against oxidative stress (19,65-67).

In turn, fish contains unsaturated fatty acids such as eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) that prevent lung damage, mainly through anti-inflammatory pathways (63). The anti-inflammatory activity of these essential fatty acids can reduce the eicosanoids formation, which has pro-inflammatory characteristics, derived from arachidonic acid metabolism (68). On the other hand, dairy products could influence the immune system response to COVID-19 through vitamin D, which reduces the risk of viral infections through physical barriers and natural immunity and induction of the innate immune system (64,69).

Therefore, the evidence with animal models and human studies indicates that specific nutrients participate in the differentiation and maturation of immune cells; guarantees the integrity of physical, chemical, and biological resistant barriers; increases the activity of natural killer cells and T lymphocytes; improves the production of antibodies and favors the phagocytosis process (62). In this sense, the consumption of a diversified and varied diet, as recommended by the healthy eating guidelines, is essential to support the immune system's functioning. Furthermore, considering the benefits of these foods, especially for the immune system, governments must reinforce the food guides and food and nutrition policies to guarantee healthier food choices in a pandemic situation such as COVID-19.

This importance of healthy food for the immune system can be recognized in the study of Zhao et al. (51) that observed a lower dietary diversity among people who lived in areas with a high number of confirmed cases of COVID-19. However, it is important to mention that no food or single nutrients are capable of preventing infection by COVID-19 (70).

This review also observed unhealthy eating habits such as increased consumption of sweets, snacks, fried foods, and elevated frequency of ultra-processed foods during COVID-19 quarantine. These foods can favor the occurrence of chronic diseases such as obesity, which has been associated with complications of COVID-19 (71). The consumption of snacks favors an increase in the intake of sugar, salt, saturated fats, and substances for the exclusive use of industries, which are the main factors that contribute to the prevalence of obesity and type 2 diabetes (72,73). The high intake of sweets and fried foods have also been associated with an increased risk of insulin resistance and type 2 diabetes (74). Besides, fried foods have shown a positive association with general and central obesity among people with high-energy intake from these foods (75). Concerning ultra-processed foods consumption, a recent systematic review and meta-analysis of 14 studies, 13 cross-sectional studies, and one cohort study reported a significant association of ultra-processed foods consumption with overweight and obesity (76). Meneguelli et al. (77) in their systematic review also demonstrated a positive association between ultra-processed foods intake and excess body weight, hypertension, dyslipidemia, and components of the metabolic syndrome.

In relation to alcohol consumption, some studies reported a decrease in the intake of alcoholic beverages (17,22,39,55,58), while others showed an increased (22,36,46). In the COVID-19 pandemic, the excess consumption of alcohol, 20-40 and 30-60g / day for women and men respectively, could increase the risk of infections, promotes apoptosis of T cells, increases symptoms of bronchitis, in addition to being a risk factor for pneumonia (78,79).

In this review, we observe that emotional factors impacted the food choices and eating behavior during COVID-19 quarantine. Being bored contributed to eating unhealthier and for increased food intake, anxiety/depression influenced the eating

habits, and the increased mental stress led to changes in food amount (44,48,49,52). Quarantine is associated with interruption of the routine, which could result in boredom. Besides, continuously hearing or reading about the COVID-19 pandemic can lead to stress. Boredom has been associated with high consumption of protein, fats, carbohydrates, and energy, while stress can contribute to the greater desire for specific foods, known as “food craving” (1). Ruiz-Roso et al. (2) evaluated this desire for food in your study and showed that the increased consumption of snacks, vegetables, and dairy products significantly related to food cravings among the study population during the lockdown.

Regarding changes in body weight during COVID-19 quarantine, most studies revealed an increase in self-reported body weight and a greater perception of weight gain. This weight gain observed during the quarantine was associated with mood changes; psychological stress; increased consumption of sweets, sugary beverages, alcohol, and homemade pastries; consumption of fried foods and junk food ≥ 3 times / week; increased snacking; sedentary time ≥ 6 h / day; decreased physical activity; and eat more than usual (22,37,43,44,53,54). In this sense, the adoption of unhealthy eating habits, emotional changes, as well negative lifestyle during COVID-19 quarantine can have contributed to the weight gain in this review's analyzed studies.

The weight gain when excessive can lead to the development of obesity. Some studies have been associated obesity with complications and a worse prognosis of COVID-19 (71,80). A study conducted with 297 patients diagnosed with COVID-19 showed that overweight and obesity were independent risk factors of severe COVID-19 (81). Another study with 770 adult patients with COVID-19 demonstrated that obesity was associated with a significantly higher rate of intensive care unit (ICU) admission or death (27). In addition, a prospective cohort study including 5,795 adults and elderly

hospitalized with COVID-19 found that mortality was significantly major in higher body mass index (BMI) (82). Studies have also been associating diabetes with the severity of SARS-CoV-2 infection and mortality by COVID-19 (83,84).

Obesity contributes to establishing a low-grade chronic inflammation. The exacerbated release of cytokines such as interleukin-8 and tumor necrosis factor can aggravate lung parenchyma injury. Moreover, this situation influences the development of several disorders such as insulin resistance and oxidative stress, which also lead to a greater propensity to infections, therefore, it has direct impacts on the worsening of the disease in question (32,81,85).

Finally, in this review was observed that individuals with overweight and obesity were more likely to show negative changes in food intake and weight body during quarantine when compared to individuals with normal weight. Thus, high BMI was correlated with a greater desire for food, eat unhealthier, eat more than usual, lower diet quality, and weight gain (2,22,49,56). In addition, individuals with depression were 49% more likely to elevated frequency of ultra-processed foods consumption incidence when compared with individuals without depression (57). Those findings show that individuals with overweight, obesity, and depression during adverse situations, such as quarantine can need more support and encouragement to maintain or adopt healthy habits. Moreover, it was noticed that studies carried out at the beginning of the quarantine period already pointed to a significant change in food intake and body weight. Thereby, it is suggested that quarantine was able to quickly promote changes in the behavior of the individuals in general (2,18,44,58).

This review has limitations. The selected papers are mostly cross-sectional studies, thus, the outcomes cannot reflect the cause-effect between quarantine and changes in eating habits and body weight. Most of the studies included in this review

were online surveys, consequently, participated of the studies individuals who had access to the internet, therefore, the total sample of this review may not reflect the population in general. The data on food intake and body weight were self-reported, however, in our experience, self-reported data showed good reliability (86). The studies included in this review were heterogeneous in terms of methods of assessment of the food consumption, as well as about the study population, that presented demographic characteristics and medical conditions different.

From an epidemiological perspective, the data found in this review are of great importance, since allowed us to observe that quarantine was capable of promoting negative changes in food intake and body weight in different populations. These changes can affect the metabolic control of several chronic diseases and create an overload even bigger for the public health system. Although events that require authorities to adopt quarantine as a restrictive measure are rare, these events can be unexpected and have a variable duration. In this sense, the knowledge of these changes becomes important for authorities to direct public health policies in quarantine situations. Concerning COVID-19, future studies should be conducted to assess the long-term effects of quarantine on food intake, eating habits, and body weight.

Conclusions

The evidence found points to a change in eating habits and body weight during quarantine, mainly towards the adoption of unhealthy habits and weight gain. Some countries may still need to adopt quarantine as a control measure of the COVID-19, in these cases, public policies that encourage healthy lifestyle habits are necessary to prevent the population from changing above all their eating habits and body weight. The adoption of healthy eating habits and the maintenance of weight can be important allies of the vaccine and other treatments of the COVID-19.

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Authors' contributions: PMP, NMCO, and HHMH: conception; PMP and NMCO: literature search, selection, and extraction; PMP, NMCO, LCVC, and HHMH: authors involved in data analysis and writing the paper; and all authors: read and approved the final version of this manuscript.

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Availability of data and materials

Data sharing does not apply to this article as no datasets were generated or analyzed during the current study.

Declarations

Ethical approval and consent to participate

Not applicable

Consent for publication

Not applicable

Competing interests

PMP, NMCO, LCVC, and HHMH, no conflicts of interest.

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FIGURE 1. Flowchart based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (Moher et al. 2009).

* Other objectives: studies that did not contribute to the answer to the question raised in this review, those referring to food insecurity in this quarantine period, others that dealt with specific nutrients and not changes in food consumption in a more general way as proposed by this review.

FIGURE 2. Changes in food intake, eating behavior, and body weight during COVID-19 quarantine.

Table 1 Inclusion and exclusion criteria used in the search for articles.

Criteria	
Inclusion	Original articles
	Published in English, Portuguese or Spanish
	Conducted with adolescents, adults, and elderly individuals with or without underlying diseases
	Whose paper the main objective was to assess the influence of quarantine on changing eating habits and/or body weight
Exclusion	Reviews
	Studies conducted with children
	Original studies with animals
	Those that did not obtain relevant information to clarify the guiding question

Table 2 Summary of studies concerning eating habits during COVID-19 quarantine

Author / Year / Country	Study design	Sample / Sample size	Objective	Outcomes about eating habits
Ammar et al., 2020 Europe, North-Africa, Western Asia, and American (58)	Cross-sectional	Adults individuals (≥ 18 years) (n = 1.047)	To identify changes in mental health and multidimensional lifestyle behaviors during the confinement of the COVID- 19	<p>↑ total score of diet (4.4%)</p> <p>↑ consumption of unhealthy foods (23.3% vs. 18.42 or late-night snacking (24.4% vs. 13.9% for most of the time and 15.4% vs. 6.4% for always, p <0.001), and</p> <p>↑ number of main meals / day (14.5% vs. 6.6% for 4 main meals, 6.3% vs. 2.4% for 5 main meals and 2.8% vs. 0.8% for more than 5 main meals, p <0.001)</p> <p>↓ excessive alcohol consumption (5.4% vs. 10.1% for sometimes, 1.2% vs. 1.8% for most of the time and 0.2% vs. 0.4% for always (p <0.001)</p>
Błaszczuk-Bebenek et al., 2020 Poland (46)	Retrospective	Adults individuals (41.12 ± 13.05 years) (n = 312)	To describe the potential effect of social isolation by COVID-19 on eating habits and nutritional status of adults in Poland	<p>↑ 51.6% of people who did not ask for food outside the home during quarantine (p <0.0001)</p> <p>↑ 11.2% of the number of meals among people who ate 5 meals a day</p> <p>↑ consumption of snacks (french fries, pretzels, snacks) during quarantine (p = 0.0386)</p> <p>↑ consumption of eggs (p = 0.0022), potatoes (p = 0.0004), sweets (p = 0.0241) and canned meat (p = 0.0004) during quarantine</p> <p>↓ consumption of energy drinks (p = 0.0150) and sweet drinks (p = 0.0254) during quarantine</p> <p>↑ alcohol consumption during quarantine (p = 0.0031)</p>
Cicero et al., 2021 Italy (42)	Longitudinal	Adults and elderly individuals (64.6 ± 13.3	To assess the effect of quarantine related to	<p>↑ of food consumption (32%)</p> <p>↓ of food consumption (6.4%)</p> <p>No change in food consumption (50%)</p> <p>↑ consumption of carbohydrates (bread, pizza, pasta, and rice) (2.2%)</p>

		years) (n = 359)	COVID on smoking and eating habits of a rural population in northern Italy	↑ vegetables, healthy vegetable oils, and fruits, milk and yogurt, alcoholic beverages, coffee, sugars and sweets, low-fat meats, eggs, nuts ↓ fish, mussels, crustaceans, and legumes
Grabia et al., 2020 Poland (47)	Cross-sectional	Adults individuals and people with diabetes (17-35 years) (n = 124)	To assess the impact of the COVID-19 pandemic on nutrition and health behaviors of patients with DM	<p>↑ healthy eating (60%)</p> <p>↑ regular meals, mainly the main meals (65%)</p> <p>↑ snacks (30%)</p> <p>↑ water (48%)</p> <p>↑ fruit (44%)</p> <p>↑ vegetables (40%)</p> <p>↑ grains (37%)</p> <p>↓ fast food (32%)</p> <p>↓ convenience food (29%)</p> <p>↓ snacks (29%)</p> <p>↓ red meat (22%)</p> <p>↓ sweets (22%)</p>
Huber et al., 2020 Germany (48)	Cross-sectional	Young individuals and adults (23.3 ± 4.0 years) (n= 1.980)	To explore how food consumption changed during confinement and determine what factors impacted those changes	<p>↓ visits to restaurants (46.4% vs 1.9%) and coffee shops (48.5% vs 2.5%) during quarantine</p> <p>↓ food orders by delivery (51.8%)</p> <p>↓ consumption of ready-made foods (18.0% vs 16.0%), influenced by ↑ in physical activities (OR 2.30 [95% CI 1.42-3.84], (p <0.01) and a quantity reduced amount of food during quarantine (OR, 1.64 [95% CI 1.04–2.55], p = 0.03)</p> <p>No change in the amount of food (52.1%) in individuals with a BMI <20kg / m², eutrophic BMI, and > 25kg / m²</p> <p>↑ of consumption in the amount of food (31.2%), more frequent in women (32.8% vs 26.6%) and in the age group of 17-25 years and those with ↑ of alcohol consumption (42.3%), smoking (42.0%) and mental stress (35.4%)</p>

				<p>↓ consumption in the amount of food (16.8%), in those with the greater practice of physical activities (OR, 1.9 [CI 1.3–2.8])</p> <p>↑ confectionery products (64.4% in those with ↑ in general consumption and 25.0% in those with ↓ in general consumption)</p> <p>↑ bread (46.8%) among people with ↑ of general consumption</p> <p>↑ meat (24.5%)</p>
Ismail et al., 2020 United Arab Emirates (54)	Cross-sectional	Adults individuals (18-55+) (n = 1.012)	To investigate the effect of quarantine on eating habits, physical activity, stress and sleep behaviors among UAE adult residents	<p>↑ home cooked meals (82.8% vs 96.2%) (p <0.001)</p> <p>↓ fast food (p <0.001)</p> <p>↑ number of 5 or more meals per day (2.1% vs 7%) (p <0.001)</p> <p>↑ breakfast (66% vs 74.2%) (p <0.001)</p> <p>↓ of those who skipped breakfast (64.2% vs 46.2%) and reported that it was due to lack of time before quarantine (62.3%) and lack of appetite (36%)</p> <p>↑ water consumption (24.1% vs 27.8%) (p = 0.003)</p> <p>No consumption of fruits (51.2%) and vegetables (37%) and milk and dairy products (46.2%) daily</p> <p>Consumption of sweets and desserts (46.1%) and snacks, cookies, and nuts (37.1%) every day</p> <p>Consumption of coffee and tea at least once a day (69.2%)</p> <p>Without energy drink consumption (86.5%)</p> <p>Lower consumption of sweet drinks and fruit juices, compared to other drinks (44.2%)</p>
Jia et al., 2020 China (50)	Retrospective	Young individuals and adults (15-28 years) (n = 10.082)	To assess changes in dietary patterns among young people in China under the COVID-19 block, based on	<p>↓ rice, meat, poultry, vegetables, fruits, soy products, and dairy products (p <0.05)</p> <p>↑ higher of rice, vegetables, and fruits by women and dairy less frequently</p> <p>↑ the higher consumption of wheat and vegetable products by men</p> <p>↑ of the higher consumption of rice by graduate students, when compared to those of high school and undergraduate</p> <p>↑ the higher consumption of canned vegetables by undergraduate</p>

			the impact of COVID-19 on lifestyle Change Survey (COINLICS)	students ↓ consumption of beverages by women, at all educational levels ↑ tea (14.8% vs 19.5%) ($p > 0.01$), by women between high school (12.9% vs 19.0%) ($p < 0.01$) and undergraduate students (11.5% vs 16.1%) ($p < 0.01$)
Jimenez et al., 2021 Spain (37)	Cross-sectional	Adults and elderly patients with a current or past history of obesity (≥ 18 years) (n= 603) Only 42.7% reported their current body weight and body mass index (BMI)	To assess the impact that the COVID-19-related lockdown (9 weeks after the stay-at-home order) had on the factors psychosocial, lifestyle, and body weight among patients with a present or past history of severe obesity	Changed dietary habits (32.5%) 75% and 81.4% not or slightly changed consumption the sugary beverages and alcohol, respectively ↑ snacking (19%) non-bariatric and bariatric >2y patients had more negative changes in regular dietary behaviors, and ↑ likelihood of weight gain compared with bariatric
Kriaucioniene et al., 2020 Lithuania (22)	Cross-sectional	Adults and elderly individuals (≥ 18 years) (n=2.447)	To investigate the effect of the COVID-19 quarantine on dietary, physical activity, and alcohol consumption habits of Lithuanians and	Ate more than usual (49.4%) ↑ snacking (45.1%) ↑ consumption of fried food (20.6%), homemade pastries (37.7%), vegetables (18.8%) and fruits (22.1%); and ↓ consumption of fast foods (41.3%), carbonated and sugary drinks (19.4%), commercial pastries (26%), vegetables (15%) and fruits (14.7%) No changes in the intake of alcoholic beverages (69.9%) ↓ alcoholic beverages (15.9%) ↑ alcoholic beverages (14.2%)

			the association between health behavior and weight changes	
López-Moreno et al., 2020 Spain (36)	Cross-sectional	Adults and elderly individuals (39.1 ± 12.9 years) (n=675)	To evaluate the effects of COVID-19 home confinement on the food habits, lifestyle, and emotional balance	<p>Changed dietary habits (54.4%)</p> <p>↑ food intake (19.6%), ↓ food intake (33.3%)</p> <p>↑ purchase of snacks (39%) and processed foods (25%)</p> <p>↑ fresh food consumption (55.7%)</p> <p>↑ number of meals/day – 5 meals / day (1% vs 23%)</p> <p>↑ alcoholic beverages (18.3%)</p>
Matsungu and Chopera, 2020 Zimbabwe (55)	Cross-sectional	Adults individuals (≥ 18 years) (n=507)	To investigate the impacts of the COVID-19 lockdown on nutrition, physical activity, and lifestyle patterns	<p>Changed diet and consumption patterns (96.6%)</p> <p>↓ consumption of the food groups ‘other vitamin A-rich fruits and vegetables’ (57.8%), ‘other vegetable’ (48.5%), ‘other fruits’ (64.9%), ‘nuts and seeds’ (45%), ‘cereals breads and tubers’ (41.1%), and ‘dairy products’ (44.9%), ↑ consumption of ‘dark green leafy vegetables’ (33.72%)</p> <p>↓ alcohol consumption (53.3%)</p>
Pellegrini et al., 2020 Italy (44)	Retrospective observational	Adults individuals undergoing weight loss (47.9 ± 16 years) (n = 150)	To evaluate changes in weight and eating habits among individuals with obesity treated in a weight loss program after 1 month of	<p>Ate more than before quarantine (40%)</p> <p>↑ number of snacks (32.7%)</p> <p>↓ consumption of fruit and vegetables (18%)</p> <p>↑ consumption of fruit and vegetables (27.3%)</p> <p>↑ fresh food (20.7%)</p> <p>↑ sweets consumption (50%)</p> <p>Factors that impacted eating habits: boredom/solitude (36%), Anxiety/depression (34.7%), and more time for cooking (32.7%)</p>

			lockdown due to the COVID-19	
Poelman et al., 2021 Netherlands (49)	Cross-sectional	Adults and elderly individuals (49.9 ± 17.0 years) (n=1.030)	To examine self-reported eating behavior and food purchases during five weeks into the COVID-19 lockdown	<p>83.3% of the participants no changed dietary habits</p> <p>Ate more than usual (8.9%)</p> <p>↑ eating unhealthier (7.1%)</p> <p>↑ eating healthier (9.6%)</p> <p>↑ sweets and snacks consumption (22.1%)</p> <p>Factors contributed to eating unhealthier during lockdown: facing more unhealthy temptations at home (35.6%), more leisure time (31.5%), being bored (21.9%), and more stress (19.2%)</p> <p>Individuals with overweight and obesity were more likely to indicate to eat unhealthier and eat more than usual during lockdown compared to individuals with a healthy weight</p>
Reyes-Olavarria et al., 2020 Chile (53)	Cross-sectional	Adults and elderly individuals (18-62 years) (n = 700)	To determine changes in eating habits and physical activity caused by confinement during the COVID-19 pandemic and analyze their associations with changes in body weight and physical activity	<p>Ate more than before (51.3%)</p> <p>Less healthy than before (26.7%)</p> <p>Healthier than before (33.7%)</p> <p>↓ consumption of vegetables and fruits (20.7%)</p> <p>↑ consumption of vegetables and fruits (30.9%)</p>

Robinson et al., 2021 United Kingdom (56)	Cross-sectional	Adults individuals (≥ 18 years) (n=2.002)	To examine weight-related behaviors, weight management barriers, physical activity levels, diet quality, and problematic overeating during the COVID-19 lockdown	<p>↑ snacked (56%)</p> <p>Factors significantly associated with lower diet quality: being younger, lower in education, and higher BMI ($p < 0.001$)</p> <p>Factors significantly associated with increased overeating: being younger, lower in education, previous psychiatric diagnosis, and higher BMI</p>
Rodríguez-Pérez et al., 2020 Spain (39)	Cross-sectional	Adults and elderly individuals (21-65 years) (n =7.514)	To examine whether confinement during the COVID-19 influenced the eating habits of the Spanish adult population	<p>↑ healthier eating habits (p-value = <0.001)</p> <p>↓ alcohol intake (57.3%)</p> <p>The majority stated that they were no longer eating during confinement (63.7%) and that they kept eating fried foods (73%)</p>
Romeo-Arroyo et al., 2020 Spain (17)	Cross-sectional	Adults and elderly individuals (42.58 ± 12.25 years) (n = 600)	To assess the perception of consumers concerning their food choices and habits during the period of confinement due	<p>↓ consumption of vegetables, meats, fruits, pasta, rice, bread, cereals, fish, sausage, dairy products, alcoholic beverages, and sweets (30%)</p> <p>↓ sweets consumption (50%)</p>

to the COVID-19				
Ruiz-Roso et al., 2020 Italy, Spain, Chile, Colombia, and Brazil (18)	Cross-sectional	Adolescents (10-19 years) (n = 820)	To investigate the nutritional changes during the COVID-19 quarantine	<p>↑ vegetables and fruits consumption (35.2% and 25.5% before and 43% and 33.2% during quarantine)</p> <p>↓ fast food consumption during quarantine (44.6% consumed less than once a week before and 64% during quarantine)</p> <p>↑ sweets consumption (14% before and 20.7% during confinement)</p> <p>↑ fried food consumption (4-7 days a week, from 7.4%, 3.7%, 1.8% and 2.1% before to 8.8%, 3.8%, 2.2% and 2.9% during confinement)</p>
Ruiz-Roso et al., 2020 Spain (2)	Cross-sectional	Adults, elderly individuals with type 2 diabetes mellitus (45-77 years) (n = 72)	To examine the impact of lockdown during the COVID-19 on eating and exercise habits, as well as the psychological effects in patients with type 2 diabetes mellitus	<p>↑ consumption of dairy products (p <0.005), vegetables (p <0.0001), snacks (p <0.001) and sugary foods (p <0.0001) during the lockdown</p> <p>↑ snack consumption ≥ 4 times/week (12.9%)</p> <p>↑ vegetable consumption ≥ 2 times / day (40%)</p> <p>No change in the consumption of drinks with sugar, nuts, cereals, legumes, fruits, meat, fish, and eggs</p> <p>Patients with BMI (35 to 40 kg/m²) significantly ↑ sugary food consumption (p = 0.001)</p> <p>Women and higher BMI ↑ food craving</p> <p>↑ consumption of snacks, vegetables, dairy products, and fruits correlated with food cravings</p>
Sánchez-Sánchez et al., 2020 Spain (40)	Cross-sectional Descriptive	Adolescent, adult, and elderly individuals (38.7 ± 12.4 years) (n=1.065)	To evaluate the eating habits, consumption, and physical activity before and after a COVID-19 confinement period	<p>↑ homemade desserts and pastries consumption (0.28% vs 4.6%; p = 0.004)</p>

Werneck et al., 2020 Brazil (57)	Cross-sectional	Adults individuals with depression or without depression (≥ 18 years) (n=41.923)	To analyze the association between previously diagnosed lifetime depression and changes in physical activity, TV-viewing, consumption of fruits and vegetables as well as the frequency of ultra-processed food consumption during the COVID-19 quarantine	Individuals without and with depression, respectively, presented a considerable incidence of low frequency of fruit or vegetable consumption [28.3% (95%CI:25.8 to 31.0) vs 31.5% (95%CI: 26.1 to 37.5)] and elevated frequency of ultra-processed food consumption [9.7% (95%CI: 8.9 to 10.7) vs 15.2% (95%CI: 13.0 to 17.7)] People with depression were 49% more likely to elevated frequency of ultra-processed food consumption incidence [OR: 1.49 (95%CI: 1.21 to 1.83)] when compared with people without depression
Zhao et al., 2020 China (51)	Cross-sectional	Adults and elderly individuals (18-80 years) (n = 1,938)	To assess food diversity among Chinese residents during the isolation period by COVID-19 and explore the as sociated factors	$\uparrow$ consumption of the cereal group (97.8%); $\downarrow$ consumption of the group of fish (57.2%), legumes (70.1%), and miscellaneous (56.9%) The age group between 18 and 45 years had a lower food diversity score Individuals living in locations where confirmed cases of Covid-19 by the laboratory were > 500 cases or living in Hubei province had a lower dietary diversity (lower HDDS)

Table 3 Summary of studies concerning body weight changes during COVID-19 quarantine

Author / Year / Country	Study design	Sample / Sample size	Objective	Outcomes about weight
Barrea et al., 2020 Italy (41)	Cross-sectional	Adults and overweight individuals (44.9 ± 13.3 years) (n = 121)	To investigate the effect of COVID-19 quarantine in the sleep quality and body mass index for Italian adults	↑ BMI in both sexes (p <0.001) ↑ significant BMI in eutrophic individuals (p = 0.023), individuals with grade I obesity (p = 0.027), grade II obesity (p = 0.020) and with no significant differences between those with overweight (p = 0.215) and grade III obesity (p = 0.871)
Błaszczuk-Bebenek et al., 2020 Poland (46)	Retrospective	Adults individuals (41.12 ± 13.05 years) (n = 312)	To describe the potential effect of social isolation by COVID-19 on eating habits and nutritional status of adults in Poland	↑ body weight from 73.47kg to 74.03kg (p <0.0001) ↑ BMI from 24.98 kg / m ² to 25.28 kg / m ² (p <0.0001)
Ismail et al., 2020 Abu Dabhi, Dubai, Sharjah, and Northern Emirates (54)	Cross-sectional	Adult individuals (18 to 55+) (n = 1.012)	To investigate the effect of quarantine on eating habits, physical activity, stress and sleep behaviors among UAE	↑ weight (40.1%), especially among those aged > 36 years (p = 0.042) and who reported a greater number of meals (p = 0.024) Weight maintenance (7.9%)

adult residents

Jimenez et al., 2021 Spain (37)	Cross-sectional	Adults and elderly patients with a current or past history of obesity (≥ 18 years) (n= 603) Only 42.7% reported their current body weight and body mass index (BMI)	To assess the impact that the COVID-19-related lockdown (9 weeks after the stay-at-home order) had on the factors psychosocial, lifestyle, and body weight among patients with a present or past history of severe obesity	<p>↑ weight (52.2%)</p> <p>Participants with weight gain rated higher for changes in mood ($p < 0.01$), sleep ($p < 0.01$), changes of dietary habits ($p < 0.01$), purchase of unhealthy and comfort foods ($p < 0.01$), increase in consumption of sugary beverages ($p < 0.01$) or alcohol ($p < 0.01$), and snacking ($p < 0.01$) than those without weight gain</p>
Kriaucioniene et al., 2020 Lithuania (22)	Cross-sectional	Adults and elderly individuals (≥ 18 years) (n=2.447)	To investigate the effect of the COVID-19 quarantine on dietary, physical activity, and alcohol consumption habits of	<p>↑ weight (31.5%)</p> <p>Maintenance or didn't know (68.5%)</p> <p>Weight gain was significantly associated with ↑ intake of carbonated or sugary drinks, homemade pastries, and fast food; ↑ snacking; eat more than usual; ↓ physical activity, and higher BMI</p>

			Lithuanians and the association between health behavior and weight changes	
López-Moreno et al., 2020 Spain (36)	Cross-sectional	Adults and elderly individuals (39.1 ± 12.9 years) (n=675)	To evaluate the effects of COVID-19 home confinement on the food habits, lifestyle, and emotional balance	↑ weight (38.8%), average weight gain of 2.57 kg, ↓ weight (31.1%), an average of 2.81 kg EEQ score was positively correlated with weight gain ($R_s = 0.19$; $p < 0.05$)
Marchitelli et al., 2020 Italy (43)	Cross-sectional	Patients with overweight or obesity with or without a psychiatric diagnosis (≥ 18 years) (n=110)	To investigate the impact of psychological and psychosocial variables on weight gain in patients affected by overweight/obesity with or without a psychiatric diagnosis during the COVID-19 lockdown	↑ weight: patients without a psychiatric diagnosis (about 50%), and with a psychiatric diagnosis (66%) Weight gain predictors on patients with psychiatric diagnosis: binge eating behaviors, which preceded the lockdown Weight gain predictors on patients without a psychiatric diagnosis: psychological stress

Martínez-de-Quel et al., 2021 Spain (38)	Longitudinal observational	Adults and elderly individuals. The sample was composed mostly of university students (35.0 ± 11.2 years) (n = 161)	To show the impact that the lockdown due to COVID-19 had on the physical activity levels, eating disorders, and sleep quality	Weight ↑ significantly when compared before and during the lockdown (67.3 ± 14.8 vs. 67.7 ± 15.1, p = 0.012) ↑ number of people in the participants' household during confinement ↑ weight gain (p = 0.217, p = 0.006)
Pellegrini et al., 2020 Italy (44)	Retrospective observational	Adults individuals undergoing weight loss (47.9 ± 16 years) (n = 150)	To evaluate changes in weight and eating habits among individuals with obesity treated in a weight loss program after 1 month of lockdown due to the COVID-19	↑ significant from the average reported weight (1.51 kg, p <0.001) and BMI (0.58 kg / m ² , p <0.001) Correlation between weight change with the consumption of sweets, and self-reported anxiety/depression
Reyes-Olavarría et al., 2020 Chile (53)	Cross-sectional	Adults and elderly individuals (18-62 years) (n = 700)	To determine changes in eating habits and physical activity caused by confinement during the	Perception of ↑ in body weight: men (25.6%) and women (38.1%) (men vs. women, p = 0.008) ↓ weight: men (19.8%) and women (14.2%) Maintenance: men (54.6%) and women (47.7%) Association of variables with body weight increase: separated marital status (p = 0.002); middle socioeconomic level (p = 0.027); consumption of fried foods ≥ 3 times / week (p <0.001), low water

			COVID-19 pandemic and analyze their associations with changes in body weight and physical activity	consumption ($p = 0.03$), low consumption of legumes ≤ 1 time / week ($p = 0.03$), consumption of junk food ≥ 3 times / week ($p = 0.04$) Weight gain: inversely association with fish consumption, physical activity and positive association with sedentary time ≥ 6 h / day
Sánchez-Sánchez et al., 2020 Spain (40)	Cross-sectional descriptive	Adolescents, adults and elderly individuals (38.7 ± 12.4 years) (n=1.065)	To evaluate the eating habits, consumption, and physical activity before and after a COVID-19 confinement period	↑ weight (52.7%) Maintenance (47.3%)
Scarmozzino and Visioli, 2020 Italy (45)	Cross-sectional	Adults and elderly individuals (20-65 years) (n = 1.932)	To evaluate the effects of the confinement on self-reported food consumption during the COVID-19, by Italians	↑ weight (19.5% of the sample)

Sidor and Rzymiski, 2020 Poland (23)	Cross-sectional	Adults and eutrophic individuals (27.7 ± 9.0 years) (n = 1.097)	To assess whether eating and drinking habits were affected during the COVID-19 quarantine	<p>↑ weight (29.9%) and ↓ weight (18.6%)</p> <p>The change in weight was correlated with BMI ($R_s = 0.21$, $p < 0.05$) and age ($R_s = 0.15$, $p < 0.05$)</p>
Zachary et al., 2020 United States (52)	Cross-sectional	Adults and eutrophic individuals (28.1 ± 12.5 years) (n = 173)	To quantify the impact that COVID-19 quarantine has on behavior associated with weight gain	<p>Maintenance of weight (59%), ↑ of weight in 5 to 10 pounds (22%), and ↓ of weight in more than 10 pounds (4%)</p> <p>Individuals who increased the weight reported the highest increase in relation to food, in relation to vision and smell, compared with those who declared that they did not change everything ($p = 0.048$)</p>

Figures

Figure 1

Flowchart based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (Moher et al. 2009). * Other objectives: studies that did not contribute to the answer to the question raised

in this review, those referring to food insecurity in this quarantine period, others that dealt with specific nutrients and not changes in food consumption in a more general way as proposed by this review.

Figure 2

Changes in food intake, eating behavior, and body weight during COVID-19 quarantine